PRESENCE OF *CHROMOGOBIUS ZEBRATUS* (KOLOMBATOVIC, 1891) (GOBIIDAE) IN THE ATLANTIC. COMMENTS ON THE SUBSPECIFIC CHARACTERISTICS AND DISTRIBUTION

by

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ABSTRACT. - The three specimens of *Chromogobius zebratus* caught at Cádiz Bay are the first of this Mediterranean restricted species found in the Atlantic, and also represent a new species for the Spanish fauna. With data of the few specimens known, statistical analysis were made to find frequency differences in the subspecific characteristics among different distribution zones of the species. The conclusion was reached that the subspecies *Chromogobius zebratus zebratus* is distributed from the Adriatic to Gulf of Cádiz, leaving *Chromogobius zebratus levanticus* restricted to the Eastern Mediterranean.

RÉSUMÉ. - Les trois spécimens de *Chromogobius zebratus* capturés dans la Baie de Cádiz sont les premiers exemplaires de cette espèce, restreinte à la Méditerranée, trouvés dans l'Atlantique. Ils représentent aussi une nouvelle espèce pour la faune espagnole. L'analyse statistique de données obtenues sur les quelques exemplaires connus, pour obtenir des différences dans les caractéristiques subspécifiques entre les différentes aires de distribution de l'espèce, a permis de conclure que la sous-espèce *Chromogobius zebratus zebratus* est distribuée depuis l'Adriatique jusqu'au Golfe de Cádiz et que *Chromogobius zebratus levanticus* est restreinte à l'est de la Méditerranée.

Key-words. - Gobiidae, *Chromogobius zebratus*, ASE, Cadiz Gulf, Spanish fauna, Distribution, Subspecies.

Chromogobius zebratus was first described in 1891 by Kolombatovic, and given the name *Gobius depressus* var. *zebrata*. Miller (1965, 1966) considered that this species ought to be included within the subgenus *Chromogobius* which had been created by De Buen in 1930, and established that the subgenus should be raised to the level of genus. Furthermore, Miller (1965, 1971) considered that the specific name *depressus* used by Kolombatovic in the initial description of the species was not correct, since the same specific name had already been used by Ramsey and Ogilby in 1887 to designate another species of the genus *Gobius* of the Australian coasts, currently known under the name *Callogobius hasseltii* (Bleeker, 1851). Therefore, according to current nomenclature (Miller, 1971), the valid name of *Gobius depressus* var. *zebrata* is *Chromogobius zebratus* (Kolombatovic, 1891). Until recently, the species *Chromogobius zebratus* has been considered restricted to the coasts of the Central and Eastern Mediterranean.

Miller (1971, 1986) believed that two subspecies of *Chromogobius zebratus* could be distinguished: *Chromogobius zebratus zebratus* and *Chromogobius zebratus levanticus*. The three specimens of *Chromogobius zebratus* captured by us - the first found outside the Mediterranean - add a new species to the Spanish fauna, and more data to clarify certain questions about the subspecies (Miller, 1977; Ahnelt, 1990).

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MATERIALS AND METHODS

The intertidal zone of the Southern Spanish Atlantic coast was explored for a total of 136 days over four years. Only 3 specimens of *Chromogobius zebratus* were found, in Playa del Chato (U.T.M. coordinates: 29SQA4540) (Fig. 1). Both the sampling localities and the method are detailed in Nieto (1991) and Nieto and Alberto (1990).

RESULTS AND DISCUSSION

Geographical distribution

Up to now, distribution records of the species *Chromogobius zebratus* have been restricted to Mediterranean coasts (Fig. 1). In the literature there are the following references:

- In the Adriatic, several specimens were captured at Split. Thirty-three were deposited in the Natural History Museum of Vienna. This Museum also holds a specimen captured at Trieste and 3 specimens from the island of Losinj (Ahnelt, 1990).
- On the coasts of Israel, 2 specimens were captured, one at Caesarea and the other at a site not known exactly (Miller, 1971).
- In the Aegean Sea, 1 specimen was reported by Miller (1977) from Rhodes.
- On Sardinia, 2 specimens were captured by Ahnelt (1990). These, together with the Corsican reference of 5 specimens (Bouchereau and Tomasini, 1989), are the only proof that this species is present in the Western Mediterranean, as records from Naples and Palermo (with the name *Gobius depressus* var. *zebrata*) given by Sanzo (1911) have not been confirmed as belonging to this species (Miller, 1971, 1986; Tortonese, 1975; Ahnelt, 1990).

The three specimens of *Chromogobius zebratus* described here, captured on the Southern Spanish Atlantic coast, are the first record of this species on the coasts of the Iberian Peninsula. Hence its known distribution, and that of the genus *Chromogobius*, considered restricted to the Mediterranean coasts, is extended to the Atlantic.

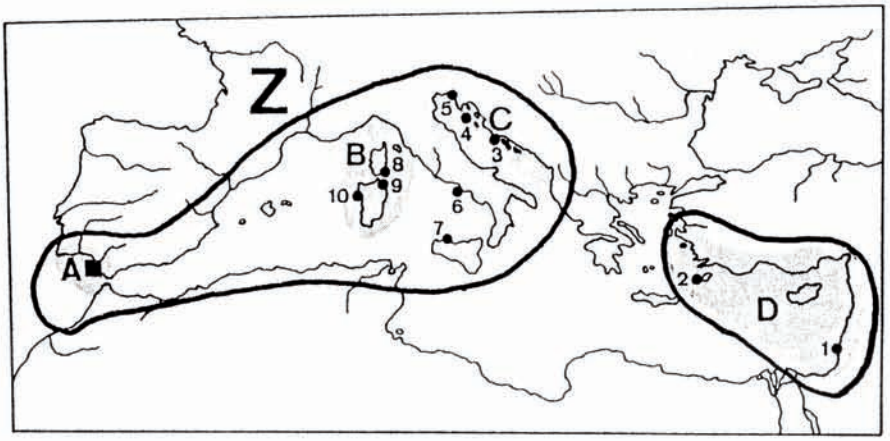

Fig. 1. - Distribution zones and localities of capture of *Chromogobius zebratus*. Zones: A = Atlantic; B = Western Mediterranean; C = Adriatic; D = Eastern Mediterranean, *Ch. zebratus levanticus* area; Z = *Ch. zebratus zebratus* area. Localities: 1 = Caesarea, Israel; 2 = Rhodes, Greece; 3 = Split, Yugoslavia; 4 = Losinj, Yugoslavia; 5 = Trieste, Italy; 6 = Naples, Italy; 7 = Palermo, Sicily; 8 = Lavezzi Islands, Corsica; 9 = Maddalena Island, Sardinia; 10 = Porto Managu, Sardinia. ■ Playa del Chato, Spain (present work).

Characteristics and biometry of the specimens

Of the 3 specimens captured, 2 were males and the other female. Sex was determined by external morphology of the urogenital papilla, very similar to that described for other species of goby (Miller, 1961). The number of scales in lateral series was 40 in two specimens and 44 in the third. Both values were within the range given by Miller (1971, 1986).

The fin-rays formulae of the three specimens were: D1: VI, D2: I+11, A: I+10, P: 16-17. These rays formulae coincide with those mentioned by other authors (Miller, 1971; Ahnelt, 1990), except that of the pectoral fin, with a range of 15-16 rays, and which was 17 in one specimen.

Table I shows the biometric data of each specimen captured. The largest was a male of 62.25 mm total length, exceeding the maximum size of 61.5 mm so far given for this species (Bouchereau and Tomasini, 1989). The head sensory papillae counts are given in table II.

Table I. - Measurements of our specimens of *Chromogobius zebratus* in mm. (m) = male, (f) = female.

	Ref. 2442 (m)	Ref. 2443 (f)	Ref. 2444 (m)
Total length	62.25	62.15	59.00
Standard length	51.30	51.00	49.15
Snout to first dorsal fin origin	16.60	18.00	16.70
Snout to second dorsal fin origin	27.00	28.25	26.30
Snout to above anus	26.00	27.60	25.80
Snout to above anal fin origin	27.90	29.00	27.20
Snout to above pelvic disk origin	13.30	13.35	13.30
Caudal peduncle length	9.70	9.80	9.20
First dorsal fin base	10.30	10.20	9.65
Second dorsal fin base	15.15	15.85	16.00
Anal fin base	12.70	12.25	12.40
Caudal fin length	11.00	9.25	9.80
Pelvic disk length	9.15	9.75	9.25
Pelvic disk origin to anus	13.30	14.00	12.20
Head length	13.00	14.20	13.40
Head width	9.25	8.90	8.80
Body depth at pelvic disk origin	6.80	6.45	6.00
Body depth at anal fin origin	6.25	6.85	6.35
Body width at anal fin origin	4.75	5.00	4.75
Caudal peduncle depth	5.25	5.20	5.25
Snout length	2.35	3.60	3.75
Eye diameter	2.30	3.00	2.60
Postorbital length	8.00	8.35	7.75
Cheek depth	3.00	2.35	2.90
Width interorbital	1.15	1.00	0.70

Systematics

Miller (1971) considered that two subspecies could be differentiated within *Chromogobius zebratus*. One was the nominal form, *Ch. zebratus zebratus*, distributed throughout the Adriatic, where Kolombatovic first described the species. The other was *Chromogobius zebratus levanticus*, of the Eastern Mediterranean (Israel) and possibly also of the Tyrrhenian Sea, since Miller (1971, 1986) considered that the specimens of Sanzo (1911) with the name *Gobius depressus* var. *zebrata*, from Naples and Palermo, were possibly of the subspecies *Ch. zebratus levanticus*, as they had 4 papillae in the *y* series.

The work of Miller (1971) was based on 15 Adriatic specimens - which he assigned to the subspecies *Ch. zebratus zebratus* - and 2 specimens from Israel, provided by A. Ben-Tuvia, which he named *Ch. zebratus levanticus*. These two subspecies were established according to the characteristics summarized in table II and detailed as follows:

a) the postorbital region lacks scales before the vertical line passing through the base of the pectoral fin in *Ch. zebratus zebratus*, while *Ch. zebratus levanticus* has scales in this region almost up to the vertical line passing through the preoperculum. However the paratype of *Ch. zebratus levanticus* presented the same arrangement of scales in the postorbital region as *Ch. zebratus zebratus* (Miller, 1971, 1986);

b) in *Ch. zebratus zebratus* there is 1 papilla in the *y* series, and none or 1 in the *m* series, while *Ch. zebratus levanticus* has from 1 to 4 papillae in the *y* series, and from 1 to 3 in the *m* series.

c) *Ch. zebratus zebratus* has 10 branched rays in the anal fin, while *Ch. zebratus levanticus* has 9.

The three specimens we captured on the Southern Spanish Atlantic coast lack scales before the vertical line passing through the base of the pectoral fin, and have 10 branched rays in the anal fin - characteristic of *Ch. zebratus zebratus*. However, the number of papillae of the oculoscapular *y* series ranges from 1 to 3, and that of the *m* series from 0 to 4. Thus papillae number appears to be more in line with the characteristics of *Ch. zebratus levanticus* (Table II), as is also the geographical distribution following Miller (1971, 1986).

This mixture of subspecific characteristics in our three specimens made it difficult to assign them to one of the two subspecies. Ahnelt (1990) found the same problem studying 37 specimens of *Ch. zebratus* from the Adriatic and 2 from Sardinia. Miller (1971) indicated the number of papillae of the *m* and *y* series as best subspecific characteristics, despite the fact that other characteristics, such as number of branched rays of the anal fin or the presence of scales in the postorbital region, seem better defined.

To determine the importance of the subspecific characteristics given by Miller (1971) and to establish similarities or differences among the samples from the various zones known for this species, we have made statistical analysis to find population differences in the frequency of characteristics between the zones of the species distribution area (see Fig. 1). For this purpose we used Fisher's exact test of independence (Sokal and Rohlf, 1981).

In principle we divided the species distribution area into four zones (Fig. 1): A- the Atlantic, with our three specimens; B-(2) Western Mediterranean, including the 5 specimens of Bouchereau and Tomasini (1989) (of which we have analysed 3) and two specimens of Ahnelt (1990); C- the Adriatic, taking in the 37 specimens studied by Ahnelt (1990). The 15 specimens of *Ch. zebratus zebratus* from this zone studied by Miller (1971) have not been considered here, since that author does not give their individual characteristics. Lastly, D- the Eastern Mediterranean, with the two specimens used by Miller (1971) to describe the subspecies *Ch. zebratus levanticus* and one specimen captured on Rhodes (Miller, 1977).

(2) We did not consider the specimens of Sanzo (1911) as we believed that they would confuse the analysis, especially since the author gives very few data about their characteristics.

Table II. - Summary of the subspecific characteristics (following Miller, 1971) of the specimens (separated by zones) noted by different authors. n = total number of specimens. In parentheses number of specimens of each type. Numbers on each side of strokes denote number of sensory papillae on each side of the specimen.

	Our specimens	Bouchereau & Tomasini (1989)	Ahnelt (1990)		Miller (1971)		Miller (1977)
Subspecies	?	*Ch. zebratus zebratus*	?	?	*Ch. zebratus zebratus*	*Ch. zebratus levanticus*	*Ch. zebratus levanticus*
Zone (see Fig. 1)	A	B	B	C	C	D	D
n	3	5	2	37	15	2	1
Scales in the postorbital region	No (3)	No (3) ? (2)	No (2)	No (36) Yes (1)	No (15)	Yes (holotype) No (paratype)	?
Sensory papillae in serie *y* - range	1-3 1/1 (1) 2/3 (1) 1/2 (1)	0-2 0/1 (1) 1/1 (1) 1/2 (1) ? (2)	1 (2)	0-3 0/0 (1) 1/0 (1) 1/1 (29) 2/1 (3) 3/1 (1) 1/3 (1) 2/2 (1)	1 (15)	1-4	2 (1)
Sensory papillae in serie *m* - range	0-4 2/0 (1) 4/2 (1) 1/2 (1)	0-1 0/0 (1) 0/1 (1) 1/0 (1) ? (2)	0-2 0/1 (1) 2/1 (1)	0-2 0/1 (27) 2/0 (3) 0/2 (2) 2/1 (2) 2/2 (3)	0-1	1-3	?
Branched rays in the anal fin - range	10 (3)	10 (5)	10 (2)	9-11 10 (35) 11 (1) 9 (1)	10 (15)	9 (2)	9 (1)

The statistical tests gave the following results:

a) it cannot be stated that there are differences between zones A, B and C in the frequency of the following characteristics: presence of scales in the postorbital region, number of branched rays of the anal fin, and number of papillae of the *m* and *y* series;

b) zone D shows a statistical difference ($p = 0.0005$) in the frequency of 9 or 10 branched rays of the anal fin, compared with each of the zones A, B and C, and also with these as a set. In contrast, zone D does not show any difference in frequency of the presence of scales in the postorbital region, with either any other zone or their set.

The number of papillae of the *m* and *y* series could not be compared between zone D and the others because Miller (1971) gives the range of this characteristic, but not the individual values, in the three specimens known in zone D.

From the result of these statistical tests, the following deductions can be made:

1) the populations of the Atlantic, Western Mediterranean and Adriatic (zones A, B and C respectively) cannot be stated as showing different frequencies in any of the subspecific characteristics analysed. Thus they can be considered as belonging to the same subspecies: *Ch. zebratus zebratus* (zone Z). This would disprove Miller's idea (1971, 1986) of Adriatic endemism for the subspecies *Ch. zebratus zebratus*.

2) the frequency of the presence of scales in the postorbital region cannot be stated as statistically different between the various zones. Nevertheless, this characteristic is linked with the presence of 9 branched rays in the anal fin in 50% of known cases, and thus could be another important subspecific characteristic when more specimens are caught.

3) up to now the only taxonomic characteristic described that shows a frequency which statistically is significantly different is the presence of either 9 or 10 branched rays in the anal fin. This occur only between zone Z (*Ch. zebratus zebratus*) and zone D (*Ch. zebratus levanticus*). Therefore we consider the number of branched rays in the anal fin as the best subspecific characteristic.

Ecology

Only a few data are available on the habitat of *Ch. zebratus*. Kolombatovic (quoted by Miller, 1971) captured specimens in the nodule interstices of certain calcareous coralline algae such as *Lithothamnion* and *Lithophyllum* frequently found close to the shore on the Mediterranean coasts. According to that author, *Ch. zebratus* is found in deeper water than the other species included in this genus, *Ch. quadrivittatus*.

One specimen of *Ch. zebratus* captured on the coast of Israel was found in a shore pool. From this same habitat, Ahnelt (1990) captured the two specimens at Sardinia, and we ourselves the three specimens at Playa del Chato. The capture of only three specimens, despite the wide area sampled and the intensity of the sampling, shows the scarcity of this species, at least in the intertidal area of that part of the Atlantic coast. Curiously, in our case, the specimens were all captured in the same pool (9.44 m^2 of surface area and 0.76 m deep), despite periodically checking a total of twelve pools at the same locality. One of the three specimens was captured in September 1988 and the other two in June 1989. The pool was very close to the low water mark, and the bottom of the pool was sandy with many loose rocks of different sizes. Apart from *Ch. zebratus*, we found in this pool *Symphodus melops*, *Gobius paganellus*, *Zebrus zebrus*, *Lipophrys dalmatinus*, *Lipophrys pholis*, *Lipophrys trigloides*, *Parablennius gattorugine*, *Parablennius incognitus* and *Scorpaena porcus*.

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